9-20-00

A

Please type a plus sign (+) inside this box → [+]

PTO/SB/05 (4/98)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	164.1014.01
First Inventor or Application Identifier	Subir VARMA
Title	Synchronized Plural Channels for Time Division Duplexing
Express Mail Label No.	EL 524 780 698 US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. [ ] * Fee Transmittal Form *(e.g., PTO/SB/17)*
(Submit an original and a duplicate for fee processing)

2. [X] Specification [Total Pages 15]
(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings *(if filed)*
- Detailed Description
- Claim(s)
- Abstract of the Disclosure

3. [X] Drawing(s) *(35 U.S.C. 113)* [Total Sheets 4]

4. Oath or Declaration [Total Pages]
a. [ ] Newly executed (original or copy)
b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d))
(for continuation/divisional with Box 16 completed)
i. [ ] DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

5. [ ] Microfiche Computer Program *(Appendix)*

6. Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
a. [ ] Computer Readable Copy
b. [ ] Paper Copy (identical to computer copy)
c. [ ] Statement verifying identity of above copies

*** NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).**

ACCOMPANYING APPLICATION PARTS

7. [ ] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
9. [ ] English Translation Document *(if applicable)*
10. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)
13. [ ] * Small Entity Statement(s) *(PTO/SB/09-12)* [ ] Statement filed in prior application, Status still proper and desired
14. [ ] Certified Copy of Priority Document(s)
(if foreign priority is claimed)
15. [X] Other: certificate of mailing

16. **If a CONTINUING APPLICATION,** *check appropriate box, and supply the requisite information below and in a preliminary amendment:*
[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: _____/_____
Prior application information: Examiner _____ *Group / Art Unit:* _____
For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS

[X] *Customer Number or Bar Code Label* 22883 *(Insert Customer No. or Attach bar code label here)* *or* [ ] *Correspondence address below*

Name					
Address					
City		State		Zip Code	
Country		Telephone		Fax	

Name (Print/Type)	Steven A. Swernofsky	Registration No. (Attorney/Agent)	33,040
Signature	Steven A. Swernofsky	Date	September 19, 2000

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

22883
PATENT TRADEMARK OFFICE

164.1014.01

Certificate of Mailing (37 C.F.R. § 1.10)

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being deposited with the United States Postal Services on the date shown below as "Express Mail" (Post Office to Addressee) in an envelope addressed to the Honorable Assistant Commissioner for Patents and Trademarks, Box Patent Application, Washington, D.C. 20231.

Mailing Label No. **EL 524 780 698 US**

Date of Deposit: September 19, 2000

Arlette Malhas
Printed Name

Arlette Malhas
Signature

Documents enclosed:

- Utility Patent Application Transmittal Form;
- Specification (10) pages;
- Claims (4) pages;
- Abstract (1) pages;
- Drawings (4) pages;
- Return post card; and
- Certificate of Express Mailing.

This application is submitted in the name of the following inventor:

Inventor	Citizenship	Residence City and State
Subir VARMA	United States	San Jose, CA
Joseph HAKIM	Canada	Sunnyvale, CA

The assignee is Aperto Networks, Inc., a California corporation having an office at 1637 South Main Street, Milpitas, CA 95035.

Title of the Invention

Synchronized Plural Channels for Time Division Duplexing

Background of the Invention

1. Field of the Invention

This invention relates to communication that uses time division duplexing (TDD) for multiple communication channels. In particular, the invention relates to synchronizing the duplexing across the plural channels, and further to assigning slots for time division multiple access (TDMA) in those channels such that consumer provided equipment (CPE) dynamically switches channels.

2. Description of the Related Art

Time division duplexing (TDD) is a well-known technique for bi-directional communication over a single frequency channel. In TDD, the channel is temporally divided into alternating upstream and downstream frames.

Communication between a base station and several consumer provided equipment (CPEs) can share a single TDD channel through use of time division multiple access (TDMA). In TDMA, the upstream frames and the downstream frames are subdivided into plural slots. The base station allocates these slots among the CPEs. At a start of each downstream frame (i.e., from the base station to the CPEs), the base station sends data to the CPEs about the slot allocation, usually using media access protocol (MAP) messages.

Sometimes, a base station communicates with plural CPEs using TDMA on plural channels. Conventionally, each CPE is assigned to a channel, and the CPE receive MAP and data bursts and sends data bursts only on its assigned channel. This arrangement is shown in Fig. 4.

CPEs A to H in Fig. 4 communicate using TDMA on channels A to D. Frames are not synchronized between channels, as illustrated by the staggered arrangement of the upstream and downstream frames between the channel.

In Fig. 4, CPEs A and B are assigned to channel A, CPEs C and D are assigned to channel B, CPEs E and F are assigned to channel C, and CPEs G and H are assigned to channel D. Thus, CPEs A and B receive downstream MAP and data bursts from a base station and send upstream data bursts to the base station on channel A. CPEs C and D receive downstream MAP and data bursts from the base station and send upstream data bursts to the base station on channel B. CPEs E and F receive downstream MAP and data bursts from the base station and send upstream data bursts to the base station on channel C. CPEs G and H receive downstream MAP and data bursts from the base station and send upstream data bursts to the base station on channel D.

As shown in Fig. 4, some of the channels are used to full capacity, preventing

additional data from being sent or received on those channels. For example, CPEs A and B cannot send additional data to the base station on channel A because the upstream frame of the channel is already fully utilized. Likewise, CPE F cannot send or receive data using channel C because CPE E is fully utilizing channel C. At the same time, some of the slots in the channels in Fig. 4 are unused. Thus, conventional channel and slot allocation can be inefficient and can lead to communication delays.

Summary of the Invention

Accordingly, what is needed is a system that more efficiently utilizes plural channels in a TDD environment.

The invention addresses the foregoing need by synchronizing frames across the plural channels so that upstream frames and downstream frames coincide across the plural channels. As a result, slots in all of the synchronized channels are available for use when a CPE needs to upload data to a base station. Likewise, slots in all of the synchronized channels are available for use when the base station needs to download data to a CPE. A controller in the base station can allocate channels and slots in those channels to the various CPEs so as to send or to receive data using slots that would otherwise be unused, thereby more efficiently utilizing the plural channels.

Accordingly, in one embodiment the invention is a method of managing TDD across plural channels. In the method, frames are synchronized across the plural channels so that upstream frames and downstream frames coincide across the plural channels.

Preferable, one channel is assigned to each of plural CPEs. Each CPE receives

MAP messages on its assigned channel. A base station controller preferably generates the MAP messages. The MAP messages instruct the CPEs to switch channels so as to receive data bursts. The base station controller preferably includes a centralized scheduler that allocates channels and slots in those channels to the CPEs for receipt of the data bursts.

In another aspect, the invention is a method of receiving TDD messages. According to the method, CPEs switch channels based on received MAP messages so as to receive data bursts on plural channels. The channel to which a CPE switches need not be the same channel as the one on which the CPE receives its MAP messages.

By virtue of the foregoing operations, the invention allows for more efficient use of channels in a TDMA environment. In particular, if a first channel on which a CPE receives MAP messages is full, a base station can allocate a slot in another channel to the CPE. The use of a centralized scheduler facilitates this cross-channel slot allocation.

The invention also can be embodied in communication systems, base stations and/or CPEs that utilize the foregoing methods. Other possible embodiments of the invention include software for implementing the foregoing methods. Additional embodiments of the invention are possible.

This brief summary has been provided so that the nature of the invention may be understood quickly. A more complete understanding of the invention may be obtained by reference to the following description of the preferred embodiments thereof in connection with the attached drawings.

Brief Description of the Drawings

Figure 1 shows a communication system in which the invention can be implemented, including a base station and plural CPEs.

Figure 2 shows frame synchronization and cross-channel slot allocation according to the invention.

Figure 3 shows a communication system in which the invention can be implemented, including an alternative implementation of the base station.

Figure 4 shows channel slot allocation according to the prior art, in which channels are not synchronized.

Description of the Preferred Embodiment

In the following description, a preferred embodiment of the invention is described with regard to preferred steps and data. However, those skilled in the art would recognize, after perusal of this application, that embodiments of the invention may be implemented using one or more general purpose processors or special purpose processors adapted to particular steps and data operating under program control, that such process steps and data structures can be embodied as information stored in or transmitted to and from memories (e.g., fixed memories such as DRAMs, SRAMs, hard disks, caches, etc., and removable memories such as floppy disks, CD-ROMs, data tapes, etc.) including instructions executable by such processors (e.g., object code that is directly executable, source code that is executable after compilation, code that is executable through interpretation, etc.), and that implementation of the preferred steps and data described herein using such equipment would not require undue experimentation or further invention.

Fig. 1 shows a communication system in which the invention can be implemented, including a base station and plural consumer provided equipment (CPEs). In Fig. 1, base station 1 communicates with CPEs 2 using antennae 3. Examples of CPEs 2 include wireless digital phones, personal data assistants (PDAs) with wireless modems, and other devices that can utilize time division duplexing (TDD). Preferably, CPEs 2 include at least transceivers that can dynamically switch between plural channels and controllers for controlling the transceivers.

Base station 1 preferably includes at least data and other I/O 5 for sending data to and receiving data from an outside source. Examples of the outside source include, but are not limited to, a computer network, a long-distance or local telephone network, a data network, and the World Wide Web. Base station 1 preferably also includes transceiver 6 for transmitting and

receiving signals over plural channels using antenna 3.

Data and other I/O interface 5 and transceiver 6 are controlled by controller 7 of base station 1. Controller 7 preferably includes at least a memory and a processor (both not shown). The memory can be a fixed memory such as DRAMs, SRAMs, hard disks, caches, etc., or removable memory such as floppy disks, CD-ROMs, data tapes, etc, or any combination of these memories. The memory preferably stores information including instructions executable by the processor and data for use during execution of those instructions. According to the invention, this data preferably includes at least a schedule of slot allocations across synchronized frames for plural channels and data for constructing media access protocol (MAP) messages for plural CPEs.

Preferably, controller 7 implements all channel control 8 for controlling communications with CPEs 2 over plural channels. Channel control 8 preferably includes centralized scheduler 9 that allocates channels and slots in those channels to CPEs 2.

Fig. 2 shows frame synchronization and cross-channel slot allocation according to the invention.

Briefly, according to the invention, frames are synchronized across the plural channels so that upstream frames and downstream frames coincide across the plural channels. One channel is assigned to each of plural CPEs. Each CPE receives MAP messages on its assigned channel. Based on received MAP messages, CPEs switch channels so as to receive data bursts. The channel to which a CPE switches need not be the same channel as the one on which the CPE receives its MAP messages.

In more detail, CPEs A to H in Fig. 2 communicate with a base station (not shown) using TDMA on channels A to D. Downstream and upstream frames are synchronized across the plural channels. In other words, when one channel is being used for downstream messages (e.g., from base station 1 to CPEs 2), the other channels also are being used for downstream messages. When one channel is being used for upstream messages (i.e., from CPEs 2 to base station 1), the other channels also are being used for upstream messages.

Base station controller 7 allocates channels and slots in those channels to the CPEs, preferably using centralized scheduler 9 of all channel control 8. Then, base station controller 7 constructs MAP messages for the CPEs and sends those MAP messages to the CPEs on their assigned channels. Thus, in Fig. 2, MAP messages for CPEs A and B are downloaded to CPEs A and B on channel A, MAP messages for CPEs C and D are downloaded to CPEs C and D on channel B, MAP messages for CPEs E and F are downloaded to CPEs E and F on channel C, and MAP messages for CPEs G and H are downloaded to CPEs G and H on channel D. Then, the various CPEs switch to the allocated channels for receiving (downloading) and sending (uploading) data in the subsequent downstream and upstream frames.

Because the upstream and downstream frames are synchronized, a CPE can switch to any one of the channels to send or to receive data. In addition, the CPEs receive MAP messages all at once, so they can switch in concert to utilize available channel slots more efficiently.

For example, in Fig. 2, data bursts to CPE E are going to fully utilize the downstream frame of channel C, leaving no slots for downloading data to CPE F on channel C. If data is going to be available for downloading to CPE F, base station 1 can allocate slot 11 in channel D to CPE F. This allocation is performed by base station controller 7, which informs

CPE F of the allocation in MAP message 12.

Likewise, base station controller 7 can allocate slots for uploading data from CPEs across the channels. Thus, in Fig. 2, slot 13 in channel B has been allocated to CPE B, slot 14 in channel D has been allocated to CPE A, and slot 15 in channel D has been allocated to CPE F.

As shown in Fig. 2, slots in plural channels can be allocated to a single CPE. Slots can be allocated both on the channel on which the CPE receives its MAP messages and on other channels. For example, slots in channels A and D have been allocated to CPE A in Fig. 2. Slots need not be allocated to a CPE on the channel on which the CPE receives its MAP messages. Thus, CPE F receives its MAP message on channel C and its data burst on channel D. Any other combinations of channel and slot allocations are possible according to the invention.

The example shown in Fig. 2 is provided only for illustrative purposed. The invention is not limited to the number and/or arrangement of channels, slots, CPEs, data bursts, MAP messages, and other details shown in Fig. 2. Instead, the invention encompasses any multichannel TDD communications in which frames are synchronized across channels, and such communications in which slots can be allocated across channels.

Fig. 3 shows another communication system in which the invention can be implemented, including an alternative implementation of the base station. In Fig. 3, a centralized scheduler and all channel control are not utilized by base station 20. Instead, controller 21 includes plural channel controllers 22, each with its own scheduler 23. In this embodiment of the invention, the channel controllers intercommunicate so as to determine slot allocation. One advantage of this embodiment is that more conventional hardware can be utilized, with a

majority of the invention implemented in revised software.

Alternative Embodiments

Although preferred embodiments of the invention are disclosed herein, many variations are possible which remain within the content, scope and spirit of the invention, and these variations would become clear to those skilled in the art after perusal of this application. For example, while the plural channels discussed above are plural frequency channels, the invention is equally applicable to situations where plural different physical channels (i.e., wires or fiber optics) are utilized, and to combinations of these frequency and physical channels. In addition, while the invention is disclosed above in a base station/CPE context, the invention is equally applicable to other point-to-multipoint communications. Other variations are possible.

Claims

What is claims is:

1. A method of managing time division duplexing across plural channels, comprising the step of:

synchronizing frames across the plural channels so that upstream frames and downstream frames coincide across the plural channels.

2. A method as in claim 1, further comprising the step of assigning one channel to each of plural consumer provided equipment, wherein each consumer provided equipment receives media access protocol messages on its assigned channel.

3. A method as in claim 2, wherein a base station controller generates the media access protocol messages, and wherein the media access protocol messages instruct the consumer provided equipment to switch channels so as to receive data bursts.

4. A method as in claim 3, wherein the base station controller includes a centralized scheduler that allocates channels and slots in those channels to the consumer provided equipment for receipt of the data bursts.

5. A method of receiving time division duplexed messages, comprising the step of:

switching channels based on received media access protocol messages so as to receive data bursts on plural channels.

6. A base station that manages time division duplexing across plural channels, comprising:

an input/output interface;

a transceiver; and

a controller that synchronizes frames across the plural channels so that upstream frames and downstream frames coincide across the plural channels.

7. A base station as in claim 6, wherein the controller further assigns one channel to each of plural consumer provided equipment, wherein each consumer provided equipment receives media access protocol messages on its assigned channel.

8. A base station as in claim 7, wherein the controller generates the media access protocol messages, and wherein the media access protocol messages instruct the consumer provided equipment to switch channels so as to receive data bursts.

9. A base station as in claim 8, wherein the controller further comprises a centralized scheduler that allocates channels and slots in those channels to the consumer provided equipment for receipt of the data bursts.

10. Consumer provided equipment the receives time division duplexed messages, comprising:

a transceiver that can dynamically switch between plural channels; and

a controller for controlling the transceiver, wherein based on received media access protocol messages, the consumer provided equipment switches channels so as to receive data bursts on plural channels.

11. A memory storing information including instructions, the instructions executable by a processor to manage time division duplexing across plural channels, the instructions comprising:

synchronizing frames across the plural channels so that upstream frames and downstream frames coincide across the plural channels.

12. A memory as in claim 11, wherein the instructions further comprise assigning one channel to each of plural consumer provided equipment, wherein each consumer provided equipment receives media access protocol messages on its assigned channel.

13. A memory as in claim 12, wherein the instruction further comprise generating the media access protocol messages, and wherein the media access protocol messages instruct the consumer provided equipment to switch channels so as to receive data bursts.

14. A memory as in claim 13, wherein the instructions further comprise allocating slots in the channels to the consumer provided equipment for receipt of the data bursts.

15. A memory storing information including instructions, the instructions executable by a processor to receive time division duplexed messages, the instructions comprising:

switching channels based on received media access protocol messages so as to receive data bursts on plural channels.

16. An apparatus for managing time division duplexing across plural channels, comprising:

means for synchronizing frames across the plural channels so that upstream

frames and downstream frames coincide across the plural channels.

17. An apparatus for receiving time division duplexed messages, comprising:

means for switching channels based on received media access protocol messages so as to receive data bursts on plural channels.

Abstract

A method of managing TDD across plural channels. In the method, frames are synchronized across the plural channels so that upstream frames and downstream frames coincide across the plural channels. Preferable, one channel is assigned to each of plural CPEs. Each CPE receives MAP messages on its assigned channel. A base station controller preferably generates the MAP messages. The MAP messages instruct the CPEs to switch channels so as to receive data bursts. The base station controller preferably includes a centralized scheduler that allocates channels and slots in those channels to the CPEs for receipt of the data bursts. Also, a method of receiving TDD messages. According to the method, CPEs switch channels based on received media access protocol messages so as to receive data bursts on plural channels. The channel to which a CPE switches need not be the same channel as the one on which the CPE receives its MAP messages. Additionally, systems, base stations, CPEs, and/or software that utilizes and/or implements these methods.

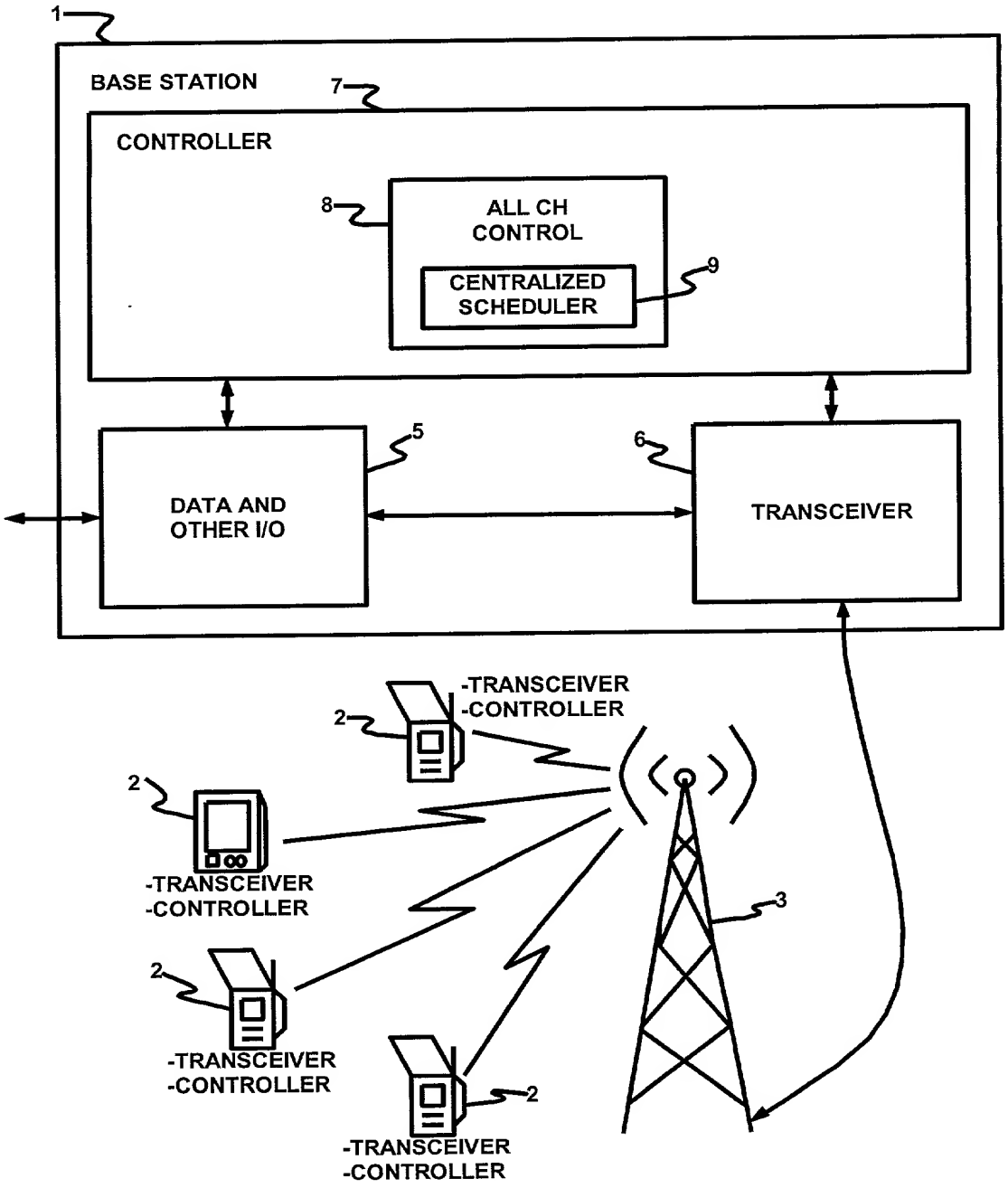

1
BASE STATION
7
CONTROLLER
8
ALL CH
CONTROL
CENTRALIZED
SCHEDULER
9
5
6
DATA AND
OTHER I/O
TRANSCEIVER
-TRANSCEIVER
-CONTROLLER
2
2
-TRANSCEIVER
-CONTROLLER
3
2
-TRANSCEIVER
-CONTROLLER
2
-TRANSCEIVER
-CONTROLLER

FIG. 1

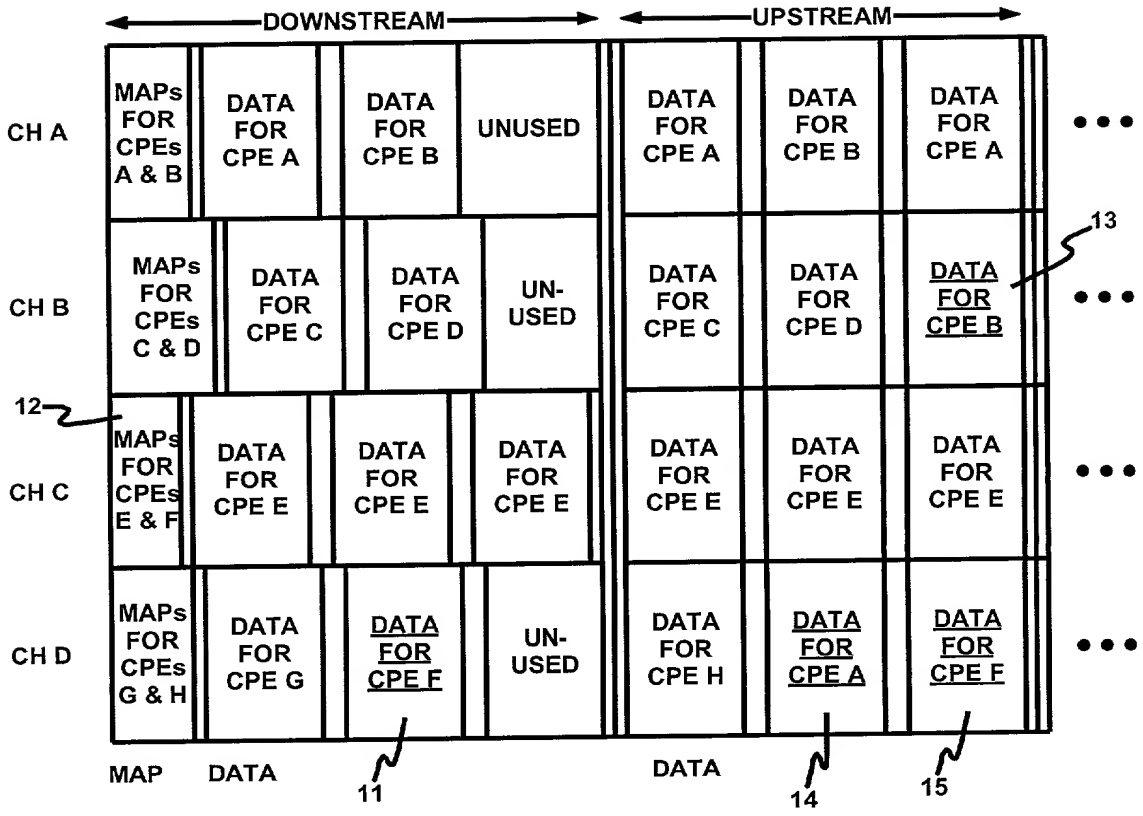

DOWNSTREAM
UPSTREAM
CH A
CH B
CH C
CH D
MAPs FOR CPEs A & B
DATA FOR CPE A
DATA FOR CPE B
UNUSED
DATA FOR CPE A
DATA FOR CPE B
DATA FOR CPE A
MAPs FOR CPEs C & D
DATA FOR CPE C
DATA FOR CPE D
UN-USED
DATA FOR CPE C
DATA FOR CPE D
DATA FOR CPE B
MAPs FOR CPEs E & F
DATA FOR CPE E
DATA FOR CPE E
DATA FOR CPE E
DATA FOR CPE E
DATA FOR CPE E
DATA FOR CPE E
MAPs FOR CPEs G & H
DATA FOR CPE G
DATA FOR CPE F
UN-USED
DATA FOR CPE H
DATA FOR CPE A
DATA FOR CPE F
12
13
MAP
DATA
DATA
11
14
15

FIG. 2

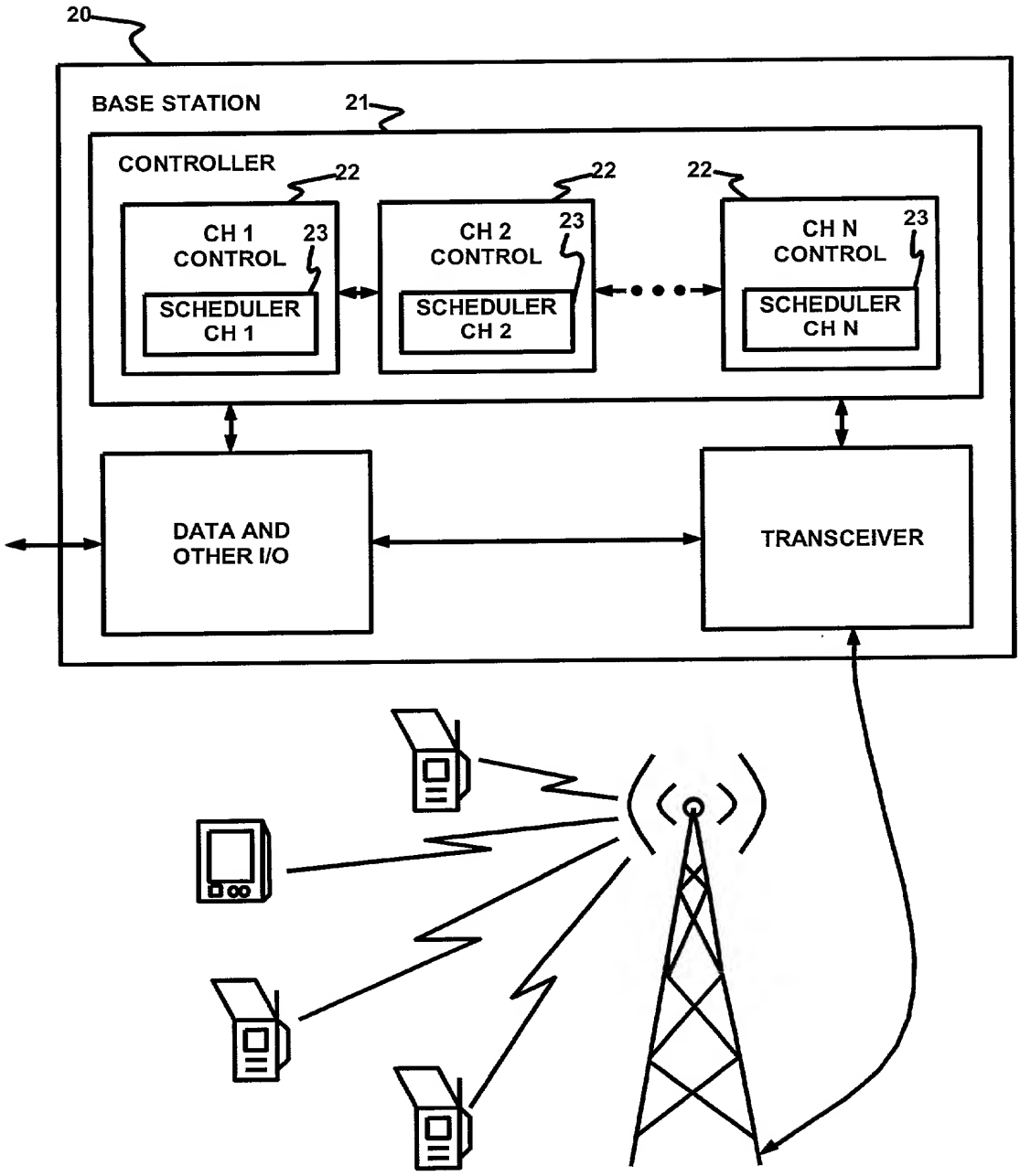
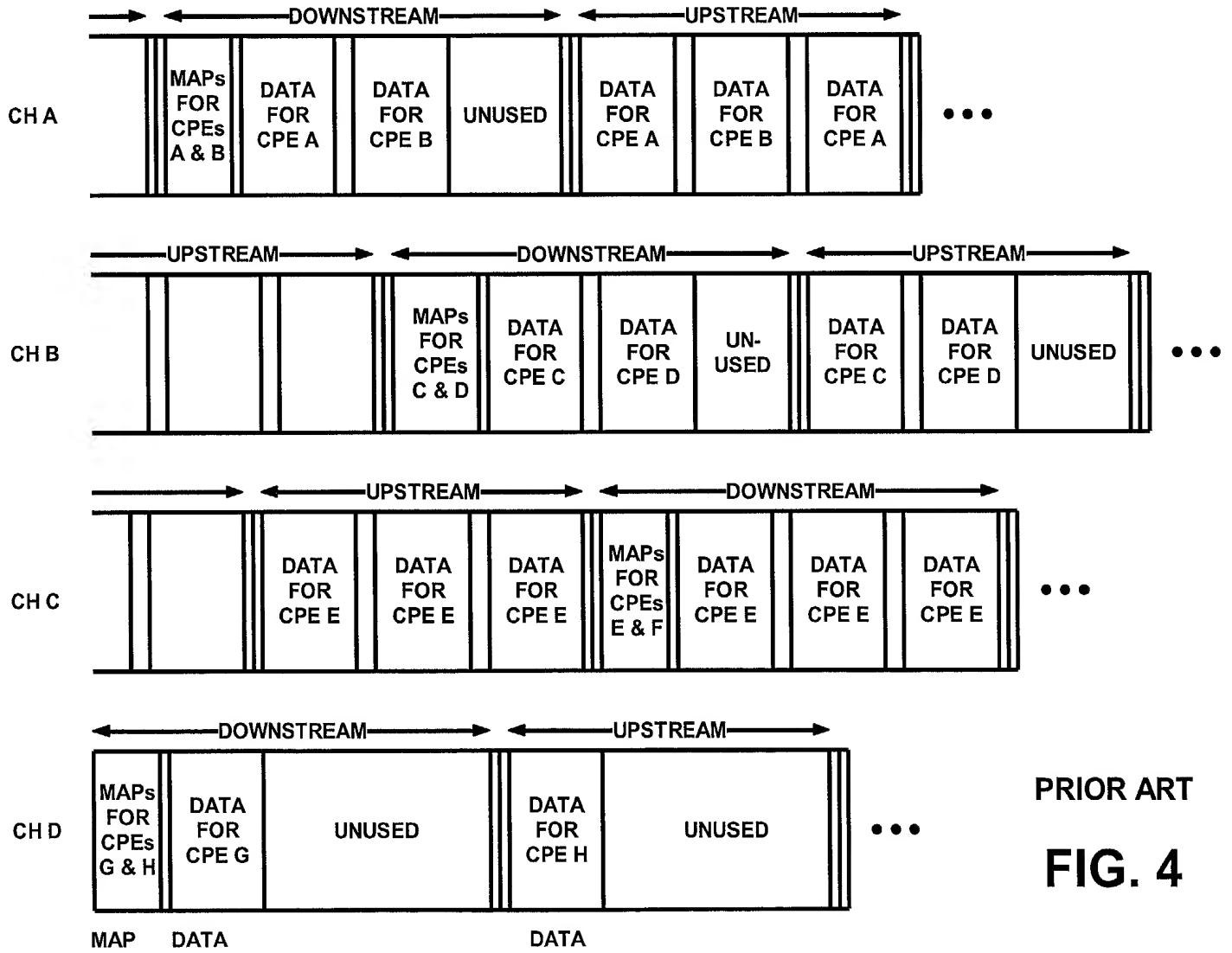

20
BASE STATION
21
CONTROLLER
22
22
22
CH 1 CONTROL
23
CH 2 CONTROL
23
CH N CONTROL
23
SCHEDULER CH 1
SCHEDULER CH 2
SCHEDULER CH N
DATA AND OTHER I/O
TRANSCEIVER

FIG. 3



PRIOR ART

FIG. 4